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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

Vladimir Volokh

Serial No.: 09/273,468

Group Art Unit:

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Examiner:

Title : MILLING CUTTER

**TRANSMITTAL OF PRIORITY DOCUMENT**

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Sir:

Applicant hereby submits a certified copy of Israeli Application 123794 for use as a priority document in the above-referenced patent application.

Respectfully submitted,

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Docket No. P-68422-US

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This **13-04-1999** **היום**

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חוק הפטנטים, תשכ"ז - 1967  
PATENT LAW, 5727 - 1967

123794

מספר:  
Number

23-03-1998

תאריך:  
Date

הוקדמת/נוחה  
Ante/Post-dated

בקשה לפטנט  
Application For Patent

אני, (שם המבקש, מענו ולגבי גוף מאורגד - מקום התאגדותו)

I (Name and address of applicant, and in case of body corporate - place of incorporation)

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חברה ישראלית  
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בעל אמצעה מכח זהין.....  
Owner, by virtue of.....  
of an invention the title of which is

כלי כרסום

(בעברית)  
(Hebrew)

MILLING CUTTER

(באנגלית)  
(English)

hereby apply for a patent to be granted to me in respect thereof

מבקש בזאת כי ניתן לי עליה פטנט

• בקשה חילוקה Application of Division		• בקשה פטנט מוסף - Application for Patent Addition		דרישת דין קידמה Priority Claim		
מספר from Application	מספר Application	לבקשת פטנט to Patent/Appl.	מספר סימן Number/Mark	תאריך Date	מדינת האיגוד Convention Country	
No. .... dated .....	מספר No. .... dated .....	מספר No. .... מיום .....				
יפוי כה : .. עוד יוגש P.O.A.: .. to be filed later הוגש בעניין ..... filed in case .....						
המען למסירת מכתבם בישראל Address for service in Israel EITAN, PEARL, LATZER & COHEN-ZEDEK P.O. BOX 33116 TEL-AVIV 61330						

חתימת המבקש  
Signature of Applicant  
Eitan, Pearl, Latzer & Cohen-Zedek

By:

1998 ....., Mar ....., 05 .....,  
החודש ....., שנת ....., 05 .....,  
of the year ....., This

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**MILLING CUTTER**

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**כלי כרסום**

The present invention relates to a Milling Cutter.

More particularly, the invention provides a new and improved tooth form for such cutters, including end mills.

Milling cutters are rotatable tools of cylindrical, conical, shaped or disk form, having a plurality of cutting edges. Such cutters are available in many forms, such as plain cylindrical, side milling cutters, face and end mills, formed cutters, and standard and special shaped profile cutters. High speed steel cutters are used for short production runs, carbide cutters are often used for long runs. One form of a cutting insert is described by Satran in U.S. Patent No. 5,685,670. Similarly to lathe tools, each cutting edge has a clearance angle which is always positive, and a rake angle which is often positive, but may be zero or negative, for example when the cutter tooth is made of a hard grade of tungsten carbide and machining is carried out at high speeds yet without a coolant. Also similar to lathe tools, the recommended relief angles and rake angles depend both on the material to be machined and the material of which the cutter is made.

Much experimentation in the course of about a century has been carried out in an effort to find the best tool tip angle for milling metals. A tool tip that has too small an included nose angle will fail to dissipate heat and quickly reach temperatures

causing softening and a sharp reduction of operating life, and/or tool failure. Also, such a tool is liable to vibrate, generate noise and may even break. Conversely a tool tip having too large a cutting angle may fail to cut without the application of high cutting forces. Both too large and too small a tooth tip angle can cause the production of a poor surface finish. Standard textbooks, such as "TOOL ENGINEERS HANDBOOK" and "MACHINERY'S HANDBOOK" provide tables of recommendations for these angles, these being based on much experience and practical tests.

Much research has been carried out to determine the largest possible volume of metal removed before tool failure, in relation to a chosen cutting speed. There are however so many additional factors involved, such as workpiece machinability rating, which itself is a function of both material type and heat treatment, tooth form, cutter size, number of teeth and cutter material, machine tool power available at the cutter and machine tool rigidity, cutter rigidity, coolant type and flow rate, surface finish required, feed rate chosen, and depth and width of cut that results published for one application are difficult to relate to other applications, even where the basic type of work, e.g. milling, is the same. It is however clear that tool tip heating is detrimental to long tool life, and anything that can be done to reduce the temperature of the tool tip will bring its reward in increased tool life.

A type of cutter used extensively is for example the cylindrical high speed steel and solid carbide end mill, which usually has helical teeth and a rake face having a rake angle positive, zero, or negative, for example say 10 degrees is common. The rake face, as viewed is usually a single concave curve extending without break from the tooth root to the cutting edge. A disadvantage of this tooth form is that there occurs extensive rubbing of the chip against the tooth rake face resulting in

high power consumption, and the production of more heat than necessary which causes tool softening. It is of course the function of the liquid coolant to remove such heat, but studies have shown that the coolant never reaches the actual cutting edge which is most in need of cooling. In practice the coolant removes heat from the body of the tool and from the workpiece, and heat is transferred by conduction from the hot cutting edge to the tool body. Tool steels are only moderately good heat conductors, so there is often a problem of too short a tool life due to a hot cutting edge.

A further problem is often encountered when using an end mill to machine a closed slot in ductile materials such as aluminium, copper, mild steel and brass in their annealed state. Chips do not clear easily out of the space between the milling cutter teeth, despite the fact that, as opposed to lathe tools, milling cutters always produce discrete chips. The conventional tooth shape previously mentioned is not helpful with regard to chip clearance.

Bearing in mind this state of the art, it is now one of the objects of the present invention to effect an improvement in milling machine cutters, particularly end mills, and to provide a tooth form having a strengthened cutting edge and improved chip disposal.

The present invention achieves the above objects by providing a rotary multi-tooth milling cutter, each tooth having a rake face comprising of at least two sections, a first section nearest the cutting edge having a convex form and a second consecutive concave section viewed in a cross section perpendicular to the cutter axis.

In a preferred embodiment of the present invention there is provided a milling cutter wherein the length of said first convex section, as measured substantially in the direction of the cutter center, comprises a substantial part of the total length of the rake face, for example the first 20% of the rake face.

In a most preferred embodiment of the present invention there is provided a milling cutter further provided with a concave chip-breaking section located around the end of the first (the convex) section.

Yet further embodiments of the invention will be described hereinafter.

It will thus be realized that the novel tooth form of the present invention serves to strengthen the tooth cutting edge, and is suitable for cutting ferrous and non-ferrous metals. The convex form encourages chip disposal and produces an improved surface finish on the workpiece.

The invention will now be described further with reference to the accompanying drawings, which represent by example preferred embodiments of the invention. Structural details are shown only as far as necessary for a fundamental understanding thereof. The described examples, together with the drawings, will make apparent to those skilled in the art how further forms of the invention may be realized.

In the Drawings:

**FIG. 1a** is an elevational view of an end mill having a tooth form according to the invention;

**FIG 1b** is an enlarged cross-sectional view of a single tooth taken at AA in **FIG. 1a** perpendicularly to the cutter axis;

**FIG. 2** is a cross-sectional view of a tooth provided with a chip breaker.

There is seen in **FIG. 1a** a rotary multi-tooth milling cutter 10. The cutter 10 is an end mill, but the tooth form to be described is applicable to various types of milling cutter.

**FIG. 1b** shows one of the cutter teeth 12 of the same embodiment in enlarged form. The tooth 12 has a rake face (or cutting surface) comprising of two consecutive sections, a first section 14 nearest the cutting edge 16 having a convex form as viewed in a cross section perpendicular to the cutter axis 18 in **FIG. 1**. The second section 20 is concave. The rake angle is indicated at "B" and the relief angle at "C". Cutting edge path is indicated at "D".

The following example illustrates the above relationships:

**EXAMPLE 1**

Type of cutter	:	End mill
Outside diameter	:	10 mm
No. of teeth	:	4
Total tooth depth	:	1.4 mm
Length of first section	:	0.28 mm
Length of second section	:	1.12 mm
Shape of second section	:	concave

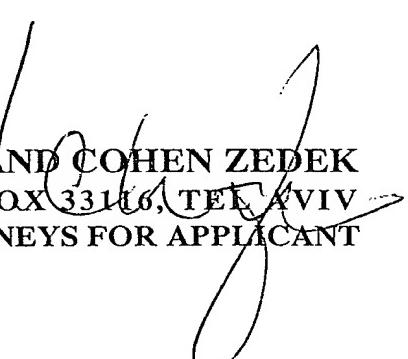
Seen in FIG. 2 is a tooth 30 of a milling cutter further provided with a concave chip-breaking section 32. The chip-breaking section 32 is located around the end of the first (the convex) section, between the first 34 and the second section 36.

The scope of the described invention is intended to include all embodiments coming within the meaning of the following claims. The foregoing examples illustrate useful forms of the invention, but are not to be considered as limiting its scope, as those skilled in the art will readily be aware that additional variants and modifications of the invention can be formulated without departing from the meaning of the following claims.

## CLAIMS

1. A rotary multi-tooth milling cutter, each tooth having a rake face comprising of at least two consecutive sections, a first section nearest the cutting edge having a convex form as viewed in a cross section perpendicular to the cutter axis, and a concaved second section.
2. The milling cutter as claimed in claim 1, wherein the length of said first section, as measured substantially in the direction of the cutter center, is for example the first 20% of the rake face.
3. The milling cutter as claimed in claim 1, wherein said first section blends tangentially into said second section.
4. The milling cutter as claimed in claim 1, further provided with a concave chip-breaking section located between said first and said second section.
5. The milling cutter as claimed in claim 1, being an end mill of HSS, Solid Carbide Cermets, Ceramics, etc.
6. A rotary multi-tooth milling cutter, substantially as hereinbefore described and with reference to the accompanying drawings.

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3 sheets  
sheet 1 of 3



**FIG. 1a**

FIG.1b

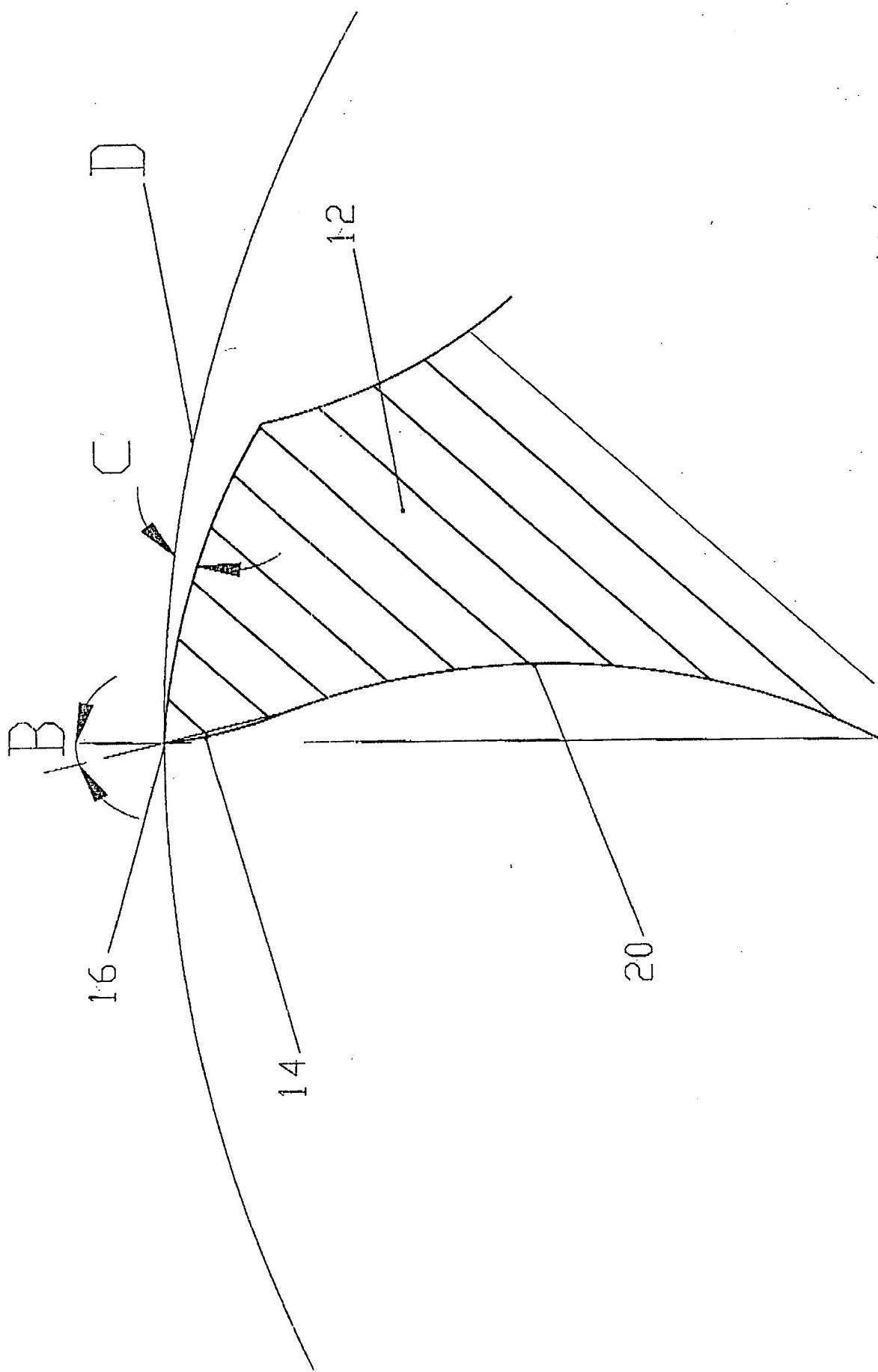


FIG. 2

